Types of Monitoring*

The term “monitor” is defined as to watch or check. Although it is not an explicit part of the definition, the term monitoring suggests a series of observations over time. This repetition of measurements over time for the purpose of detecting change distinguishes monitoring from inventory and assessment. While both inventories and assessments can be based on a single measurement or observation, they also can incorporate a series of observations to obtain a better estimate of a particular parameter. For example, the number of species of fish in a particular reach might be counted as part of an inventory of fish species, and several counts might be made in order to obtain a more accurate estimate. Similarly, maximum daily water temperature might be measured several times over the course of a summer to assess whether summer temperatures might be an important limitation to the quality of fish habitat under the existing conditions. However, if water temperatures are measured over several years to determine the effect of upstream management activities or climatic variations, this is clearly monitoring. The overlap in the definitions of assessment, inventory, and monitoring means that in some cases the primary distinguishing feature of monitoring will be the intent to assess change rather than the number or type of measurements.

Often an assessment or inventory serves as the first step towards establishing a monitoring project. Knowledge of the spatial and temporal variability is essential to developing an efficient monitoring plan. Inventory and assessment techniques overlap with monitoring procedures.

A number of federal and state agencies have defined the different types of monitoring carried out by their particular organization. Unfortunately, these definitions are not consistent, and this has often resulted in semantic confusion. In most cases a clear statement of the purpose of the monitoring will be the best method of defining the type of monitoring, and it then is simply a matter of attaching a mutually agreeable label to that particular type of monitoring.

It should be emphasized that the following seven types of monitoring are not mutually exclusive. Often the distinction between them is determined more by the purpose of monitoring than by the type and intensity of measurements. Regular sampling of coliform bacteria to meet health standards, for example, will produce data that also can be used to indicate long-term trends. The following table describes monitoring types according to the parameters being measured, the frequency of monitoring, the duration of monitoring, and the intensity of data analysis. At this point no consensus exists on the definitions of monitoring types, and this, together with the proliferation of monitoring terminology, means that each monitoring plan should explicitly define the monitoring terminology being used.

Most water quality monitoring projects will involve more than one type of monitoring. Distinct objectives attained through different types of monitoring do not necessarily require distinct and independent collection efforts. There is often considerable overlap in terms of data needs, and recognition of this can result in cost savings.
General Characteristics of Monitoring Types

<table>
<thead>
<tr>
<th>Type of Monitoring</th>
<th>Number and Type of Water Quality Parameters</th>
<th>Frequency of Measurements</th>
<th>Duration of Monitoring</th>
<th>Intensity of Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trend</td>
<td>Usually water column</td>
<td>Low</td>
<td>Long</td>
<td>Low to moderate</td>
</tr>
<tr>
<td>Baseline</td>
<td>Variable</td>
<td>Low</td>
<td>Short to medium</td>
<td>Low to moderate</td>
</tr>
<tr>
<td>Implementation</td>
<td>None</td>
<td>Variable</td>
<td>Duration of project</td>
<td>Low</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>Near activity</td>
<td>Medium to high</td>
<td>Usually short to medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Project</td>
<td>Variable</td>
<td>Medium to high</td>
<td>&gt; Project duration</td>
<td>Medium</td>
</tr>
<tr>
<td>Validation</td>
<td>Few</td>
<td>High</td>
<td>Usually medium to long</td>
<td>High</td>
</tr>
<tr>
<td>Compliance</td>
<td>Few</td>
<td>Variable</td>
<td>Dependent on project</td>
<td>Moderate to high</td>
</tr>
</tbody>
</table>

1. **Trend monitoring.** In view of the definition of monitoring, this term is redundant. Use of the adjective “trend” implies that measurements will be made at regular, well-spaced time intervals in order to determine the long-term trend in a particular parameter. Typically, the observations are not taken specifically to evaluate management practices (as in type 4), management activities (as in type 5), water quality models (as in type 6), or water quality standards (as in type 7), although trend data may be utilized for one or all of these other purposes.

2. **Baseline monitoring.** Baseline monitoring is used to characterize existing water quality conditions and to establish a data base for planning or future comparisons. The intent of baseline monitoring is to capture much of the temporal variability of the constituent(s) of interest, but there is no explicit end point at which continued baseline monitoring becomes trend monitoring. Those who prefer the terms “inventory monitoring” and “assessment monitoring” often define them such that they are essentially synonymous with baseline monitoring. Others use baseline monitoring to refer to longterm trend monitoring on major streams.

3. **Implementation monitoring.** This type of monitoring assesses whether activities were carried out as planned. The most common use of implementation monitoring is to determine whether Best Management Practices (BMPs) were implemented as specified in an environmental assessment, environmental impact statement, other planning document, or contract. Typically, this is carried out as an administrative review and does not involve any water quality measurements. Implementation monitoring is one of the few terms which has a relatively widespread and consistent definition. Many believe that implementation monitoring is the most cost-effective means to reduce nonpoint source pollution because it provides immediate feedback to the managers on whether the BMP process is being carried out as intended. On its own, however, implementation monitoring cannot directly link management activities to water quality, as no water quality measurements are being made.

4. **Effectiveness monitoring.** While implementation monitoring is used to assess whether a particular activity was carried out as planned, effectiveness monitoring is used to evaluate whether the specified activities had the desired effect. Confusion arises over whether effectiveness monitoring should be limited to
evaluating individual BMPs or whether it also
can be used to evaluate the total effect of an
entire set of practices. The problem with this
broader definition is that the distinction be-
tween effectiveness monitoring and other
terms, such as project or compliance monitor-
ing, becomes blurred.

Monitoring the effectiveness of individual
BMPs, such as the spacing of water bars on
skid trails, is an important part of the overall
process of controlling nonpoint source pollu-
tion. However, in most cases the monitoring
of individual BMPs is quite different from
monitoring to determine whether the cumula-
tive effect of all the BMPs results in adequate
water quality protection. Evaluating individ-
ual BMPs may require detailed and specialized
measurements best made at the site of, or
immediately adjacent to, the management
practice. Thus, effectiveness monitoring often
occurs outside of the stream channel and
riparian area, even though the objective of a
particular practice is intended to protect the
designated uses of a water body. In contrast,
monitoring the overall effectiveness of BMPs
usually is done in the stream channel, and it
may be difficult to relate these measurements
to the effectiveness of individual BMPs.

5. Project monitoring. This type of monitoring
assesses the impact of a particular activity or
project, such as a timber sale or construction
of a ski run on water quality. Often this as-
essment is done by comparing data taken
upstream and downstream of the particular
project, although in some cases, such as a fish
habitat improvement project, the comparison
may be on a before and after basis. Because
such comparisons may, in part, indicate the
overall effectiveness of the BMPs and other
mitigation measures associated with the pro-
ject, some agencies consider project monitor-
ing to be a subset of effectiveness monitoring.
Again, the problem is that water quality is a
function of more than the effectiveness of the
BMPs associated with the project.

6. Validation monitoring. This refers to the
quantitative evaluation of proposed water
quality model. The data set used for validation
should be different from the data set used to
construct and calibrate the model. This separa-
tion helps ensure that the validation data will
provide an unbiased evaluation of the overall
performance of the model. The intensity and
type of sampling for validation monitoring
should be consistent with the output of the
model being validated.

7. Compliance monitoring. This is the monitor-
ing used to determine whether specified water
quality criteria are being met. The criteria can
be numerical or descriptive. Usually the
regulations associated with individual crite-
rion specify the location, frequency, and
method of measurement.

Monitoring Concepts
for Rangeland Management**

**Short-term Monitoring**

Short-term monitoring involves collecting
and recording vegetation and other resource
characteristic information within a year, mainly
for day-to-day and annual management deci-
sions. Short-term monitoring focuses on such
questions as: Is the grazing occurring as planned?
Are there outside influences on the vegetation?
What changes should be made now or next year
to better meet management objectives? Short-
term monitoring also provides essential informa-
tion for interpreting long-term monitoring stud-
ies.

Recommended short-term monitoring practices
include:

Vegetation evaluation—Systematic observations
or sampling during the growing season for cover,
yield, and/or species composition.

Climate records—Precipitation, temperature,
etc. (This may be accomplished by summarizing
available USDC weather records.)

Residue maps—Identification of areas where too
much or too little grazing is occurring by map-
ning residual dry matter (RDM) at high, low, and
moderate levels after livestock are removed from
pastures or during late September or early October.

**Actual use records of livestock grazing**—Livestock numbers, types and dates, animal condition score and/or weights (actual or estimated) in and out of pastures. The UC Cooperative Extension Pasture Inventory Program (George, Bell, and Lasarow 1987) can help you handle this information systematically.

**Unplanned disturbances**—Recording fires, wildlife use, insect and weed infestations, acts of vandalism, etc.

**Long-term Monitoring**

Long-term monitoring involves documenting measurements and observations for several years on study sites selected within the management area, grazing lease, pasture or areas of specific concern. Conducting measurements and/or observations over several years provides a trend. Site locations and types of data to be collected are determined by the management plan’s objectives. Records must be carefully maintained, protected, and made available for planning.

A long-term monitoring program should include:

- **Trend transects**—Systematic measurements (every 3 to 5 years) of the vegetation or other resource characteristics.

- **Trend photo points**—Permanently established points at which photos are taken annually of a general view and one or more close-ups of important resource characteristics.

- **Aerial photos**—Regularly scheduled photos of the same area to show major vegetation changes in brush, trees, and grasslands.

---

**Sources:**